SINAPSE
Scottish Imaging Network - A Platform for Scientific Excellence

SINAPSE

PhD Project Proposal Template for PhDs with Industry starting in 2010

PROJECT
Title:

Fluid dynamics assessment of spiral flow inducing intravascular stents.

Planned start date (month/year):

October 2010

SINAPSE Centre (i.e. primary university to which this studentship will be attached):

Dundee

University first supervisor: contact details

Name: Prof Graeme Houston **Department: Clinical Radiology** **Address: Ninewells Hospital and Medical School, Dundee DD1 9SY** **Email: ghouston@nhs.net** **Phone: 01382 632651**

Formatted: French (France)

Second academic supervisor/ other university or other people in primary university involved with project

Prof Ian Marshall, Head of Medical Physics & Medical Engineering, Centre for Cardiovascular Science, University of Edinburgh **Prof Peter Stonebridge**, Dept Vascular Surgery, Ninewells Hospital ,University of Dundee

Industry

Tayside Flow Technologies Ltd, DD2 1TY

Industry main contact details

Name: Mr David Lawrence **Department: CEO** **Address: Prospect Business Centre, Technology Park, Dundee DD2 1TY** **Email: david.lawrence@tayflow.com www.tayflow.com** **Phone: 01383 598532**

Formatted: French (France)
Formatted: French (France)
Formatted: French (France)
Field Code Changed

Key Other Industry people involved with Project including Industry Supervisor (if different to Industry main contact above)

Mr Richard Nelson – Project Manager **Mr Robert Hood – R&D Manager**

Scottish Imaging Network - A Platform for Scientific Excellence

Likely background of suitable student (eg. Neuroscience, MR Physics, Chemistry, Engineering, Informatics, Psychology) and essential skills required prior to starting this PhD:

The background of the suitable student would be Engineering, or Fluid Dynamics in Physics, ideally with imaging experience.

The essential skills would be the potential to work between multiple disciplinary research themes, ie. Engineering, Physics, Medical Sciences and also industry

Summary of proposed project (approximately 200 words):

The concept of spiral laminar flow being the normal physiological arterial flow pattern has been by physiological observations on the circulatory system itself: by the way that the heart is twisted on its axis and the aortic arch is tapered, curved and twisted; by the results of computer simulations of pulsatile flow in curved distensible vessels, reported by Hung [1], which also indicated that the dominant flow pattern was spiral; and by additional published reports of the in vivo demonstration of spiral laminar flow in a variety of anatomic locations (2).

The initial observations of in vivo spiral laminar flow stimulated the TFT research into understanding the improved flow conditions achieved by spiral flow. These are reduced turbulent kinetic energy,reduced near wall turbulence,both in uniform straight conduits and through conduits with focal narrowings (stenoses)(3-5). The reduction in near wall turbulence was hypothesised to reduce intimal damage and thereby protect against both atheroma in native vessels, and neo-intimal hyperplasia in implanted devices, including intravascular stents.

In order for TFT to develop an intravascular spiral flow inducing stent,the iterative process of prototypes produced will need to be evaluated in a flow rig and also in computational fluid dynamics modelling ideally in conduits that mimic the proposed artery for implantation.

The key research questions are:

1) Do the prototype spiral stents produce spiral flow in the physiological flow rig?
2) Does the implanted vessel geometry affect the flow pattern and haemodynamic effects of the spiral stent.
3) Does the spiral flow pattern observed result in a reduction of near wall turbulent kinetic energy both within the stent and downstream?

This project will undertake to test the spiral arterial stent or design e.g. for femoropopliteal arterial implantation by:

a) Physiological flow rig testing to determine the flow pattern produced and length of propagation down the conduit by prototypes.
b) MRI flow and flow pattern analysis of implantation i.e. femoropopliteal vessel in normal physiological conditions. e.g. straight or bent knee.
c) Computational fluid dynamics testing of the prototype stent design to determine the turbulence profile, the shear stress and normal stress both within an downstream form the stent.

The output of the project will lead to the optimal configuration of the final product for preclinical and ultimately clinical trial, and provide the regulatory data for the design history file.

Key references (up to five):

1. Hung TH. Pulsating spiral blood flow in curved arteries. In: Norman J, ed. *Cardiovascular science and technology, basic and applied.* Louisville, Kentucky: Oxymoron Press. 1989: 124-126.
2. Frazin LJ, Vonesh MJ, Chandran KB, Shipkowitz T, Yacoub AS and McPherson DD. Confirmation and initial documentation of thoracic and abdominal aortic helical flow - An ultrasound study. *Asaio J*. 1996, **42**: 951-956.
3. Non spiral and spiral (helical) flow patterns in stenoses. In vitro observations using spin and gradient echo magnetic resonance imaging (MRI) and computational fluid dynamic modeling. *Stonebridge PA, Buckley C, Thompson A, Dick J, Hunter G, Chudek JA, Houston JG, Belch JJ. Int Angio). 2004 Sep;23(3):276-83*.
4. Houston JG, Gandy SJ, Sheppard DG, Dick JB, Belch JJ and Stonebridge PA. Two-dimensional flow quantitative MRI of aortic arch blood flow patterns: effect of age, sex and presence of carotid atheromatous disease on prevalence of spiral blood flow. *J Magn Reson Imaging.* 2003, **18**: 169-174.
5. Houston JG, Gandy SJ, Milne w, Dick JB, Belch JJ and Stonebridge PA. Spiral laminar flow in the abdominal aorta: a predictor of renal impairment deterioration in patients with renal artery stenosis? *Nephrol Dial Transplant.* 2004, **19 (7)**: 1786-1791.